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Transdisciplinary deficit in large carnivore conservation funding in Europe

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Abstract

Achieving coexistence between humans and large carnivores in human-shaped landscapes is a complex challenge. Addressing this challenge requires the revaluation of the approaches academia uses to foster carnivore conservation and human-large carnivore coexistence. In this forum paper, we provide a brief overview of the three archetypical approaches of knowledge generation for large carnivore conservation in human dominated landscapes (disciplinary, interdisciplinary and emerging transdisciplinary approaches) and highlight the need for more explicit consideration of transdisciplinarity in large carnivore conservation funding. We refer to transdisciplinary deficit (TDD) for those situations when the context allows the implementation of transdisciplinarity but research and practice remains disciplinary or interdisciplinary. We identify drivers of this TDD and provide a brief overview of current and past conservation funding programmes at the European level in terms of their capacity to promote transdisciplinary approaches for large carnivore conservation. We show that current funding programmes favour sectorial and disciplinary approaches, resulting in low transdisciplinary substance in large carnivore conservation projects. TDD can be overcome by transforming the character of public funding towards multi-stakeholder collaboration, designing and nurturing effective communities of practice, and reducing co-financing rates for large, integrated projects.

Keywords

conservation funding, EU funding programmes, large carnivore conservation, stakeholder involvement, transdisciplinarity

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Introduction

The future of large carnivores in human-shaped landscapes is currently debated in the academic and policy worlds and is recognised as a complex challenge (Hartel et al. 2019). This complexity arises from several factors. First, large carnivores require extensive territories, which often results in overlap with areas used by humans, and subsequently, various forms of human-wildlife conflict arise, with potential for severe economic losses or even human injuries or deaths (Linnell et al. 1999; Treves and Naughton-Treves 1999; Carter and Linnell 2016; Morehouse and Boyce 2017; Van Eeden et al. 2018; Bombieri et al. 2019, 2021). Second, there are often divergent societal views on how to best resolve subsequent human-wildlife conflicts due to different values associated with carnivores (López-Bao et al. 2017a, b; Swan et al. 2017; Lute et al. 2018; Salvatori et al. 2020; Marino et al. 2021). For example, large carnivores may have high economic values (e.g. for hunting and/or tourism) (Penteriani et al. 2017; Gren et al. 2018), may reduce wildlife-vehicle collisions (Gilbert et al. 2017), and may promote the conservation of ecosystems as umbrella species (Noss et al. 1996; Linnell et al. 2005; Ripple et al. 2014). At the same time, large carnivores may compete with humans for the same food resource (Treves and Karanth 2003; Suraci et al. 2016; Sévêque et al. 2020), may cause collisions with vehicles (Redpath et al. 2014), especially if linear transport corridors are not permeable (Morales-González et al. 2020). Third, global change is likely to drive changes in the behaviour and distribution of large carnivore species (Penteriani et al. 2019; Titley et al. 2021), to which other societal challenges, such as food security, increasing demand for space, fertile land and rising human resource consumption and changing land ownership with the related land use regimes add complexity (Hartel et al. 2019). Finally, in regions such as the European Union (EU), all large carnivore species are strictly protected through the Habitats Directive 92/43/EEC (European Commission 1992), with some exceptions (see Box 1 for further details about the status of large carnivore species in EU, including relevant legal protection instruments). In addition, European action plans have been developed for each species to guide their conservation (Boitani 2000; Breitenmoser et al. 2000; Delibes et al. 2000; Landa et al. 2000; Swenson et al. 2000).

The goals of this paper are to: (1) highlight the disciplinary, interdisciplinary and transdisciplinary approaches used to address large carnivore conservation in Europe, (2) outline the drivers of transdisciplinary deficit (TDD), (3) provide a brief overview of EU funding for implementing transdisciplinary projects, and (4) offer recommendations to improve the transdisciplinary substance of large carnivore conservation projects.

Transdisciplinarity and the transdisciplinary deficit

Transdisciplinarity is the co-creative process of elicitation and integration of knowledge from science and society in order to generate actionable knowledge to address various sustainability challenges and problems (Lang et al. 2012). Transdisciplinarity is viewed by some authors as the cornerstone of sustainability transformations (Renn 2021).

Box 1. Large carnivore species and their status in the EU.

The EU is home to five large carnivore species, namely to the: brown bear (*Ursus arctos* L.), gray wolf (*Canis lupus* L.), Eurasian lynx (*Lynx lynx* L.), Iberian lynx (*Lynx pardinus* T.) and wolverine (*Gulo gulo* L.) (European Commission 2015).
There are around 17,000 brown bear individuals, 12,000 wolves, 9,000 Eurasian lynxes and 1,250 wolverines in Europe (Chapron et al. 2014). The most endangered species, the Iberian lynx, is estimated to have more than 1,000 individuals after a comprehensive reintroduction programme (Delibes-Mateos et al. 2022). Trend: generally increasing (Chapron et al. 2014), as a result of favourable EU policies and various conservation efforts, including the implementation of reintroduction projects (Ripple et al. 2014).

Conservation status of large carnivore species in EU
Bear – Near Threatened, wolf – Least Concern, Eurasian lynx – Near Threatened, Iberian lynx – Critically Endangered, wolverine – Vulnerable (Temple and Terry 2007).

Key EU legislation and policies relevant to large carnivore species
All five large carnivore species present in the EU are protected by the Habitats Directive (Directive 92/43/EEC), being included in its Annex II (Animal and plant species of community interest whose conservation requires the designation of special areas of conservation) and IV (Animal and plant species of community interest in need of strict protection) (except for some wolf populations in e.g. Spain, Greece, Northern Europe).
In addition, the European Commission (2015) created the EU Platform on coexistence between people & large carnivores "to promote ways and means to minimise, and wherever possible find solutions to, conflicts between human interests and the presence of large carnivore species, by exchanging knowledge and by working together in an open-ended, constructive, and mutually respectful way."
The relevant EU strategies that can significantly contribute to the conservation of large carnivores are the EU Biodiversity Strategy for 2030 (Hermoso et al. 2022), which creates the frame for developing binding nature restoration targets, and the European Green Deal (European Commission 2020). The Strategic Environmental Assessment (required by the SEA Directive 2001/42/EC), the Environmental Impact Assessment (required by the EIA Directive 85/337/EEC) and Appropriate Assessment (required by the Habitats Directive 92/43/EEC) can further contribute to a higher level of protection of large carnivores and their habitats by assessing the impact of different strategies, plans, programmes or projects on them. The Aarhus (UNECE & REC 2014), ESPOO (European Union 2013) and CITES (UNEP-WCMC 2022) conventions can also be key legal instruments for large carnivores' protection. Dedicated international action plans can also contribute to large carnivores' conservation (Papp et al. 2020). Other relevant international legal instruments are provided by Trouwborst (2015).

Main threats to large carnivores
Main threats include: habitat fragmentation, loss and degradation (caused especially by the development of linear transport infrastructures, human settlement expansion and intensive agriculture), illegal hunting and human persecution (often due to human-large carnivores conflicts), reduction of the prey base (e.g. Trocmé et al. 2003; Ripple et al. 2014; Wolf and Ripple 2017, 2018; Ferreira et al. 2018; Morales-González et al. 2020; Papp et al. 2022).

Transdisciplinary approaches require engaging key institutional and political actors, stakeholders and interest groups in co-designing projects, co-producing knowledge and co-creating solutions for mainstreaming their coexistence (Ceauşu et al. 2019; Hartel et al. 2019). Although stakeholder interactions are essential to, and implemented to some extent, in large carnivore conservation projects, these interactions often fail to trigger the desired genuine deliberations and internalisation processes (Kenter et al. 2019), which could result in effective stewardship groups to ensure coexistence in human-shaped landscapes (Buschke et al. 2019).

While the importance of the human component is typically recognized by ecological restoration and biological conservation project funding agencies as well as in major nature conservation policies within the EU (e.g. the Habitats Directive (European Commission 1992), the Common Agricultural Policy (Heyl et al. 2020)), this recognition itself is not a guarantee of transdisciplinarity (Table 1). This disconnect highlights the need for conservation funding bodies to explicitly request or at least demonstrably encourage transdisciplinarity with the local and broader communities relevant to large carnivore conservation. As Table 1 exemplifies, people can be involved in large carnivore and broadly, nature conservation projects through three archetypical approaches: disciplinary, interdisciplinary and transdisciplinary. These approaches are based on dif-

ferent ontologies and epistemologies as well as on different ways to perceive the role of science in society. The potential of conservation projects to foster values and cultural transformation towards protecting large carnivores and nature in human-shaped landscapes will remain low if only disciplinary and interdisciplinary approaches are fostered by project funding (Table 1). Several recent calls have been made to better embrace the social component in understanding and managing natural environments (e.g. De Snoo et al. 2012; Popescu et al. 2014; Bennett et al. 2016). With the increasing manifestation of the social-environmental vulnerabilities related to global change, calls have also been made for creating genuine cross-sectorial and cross-disciplinary bridges to foster transformation of knowledge systems for sustainability (Fazey et al. 2020; Turnhout and Lahsen 2022).

While transdisciplinary projects could improve large carnivore conservation outcomes in human- shaped landscapes, recent literature reviews suggest that transdisciplinary approaches are scarcely reported in academic journals targeting large carnivore conservation (Hartel et al. 2019; Lozano et al. 2019; Table 1) and transdisciplinarity is not explicitly considered in conservation funding projects. We refer to this shortcoming as a transdisciplinary deficit 'TDD' in large carnivore conservation. TDD arises even when substantial resources are allocated to protect large carnivores in human-shaped landscapes, but the real world *status quo* does not change substantially as a result of the projects. In extreme cases, we speculate that the gap between key institutions and stakeholders, as well as the tensions and conflicts between stakeholders, may even increase after such projects. Below, we highlight 12 key drivers of TDD.

Key drivers of transdisciplinary deficit

We present 12 key interlinked drivers that can lead to TDD, based on our combined experience in large carnivore conservation, as well as the broader conservation and sustainability science literature. Our intention is to share our insights in order to foster new thinking, reflection and future improvement through assessments and documentation; our list should not be considered exhaustive, but rather a starting point.

Project and implementation team related drivers

Narrow and/or preferential stakeholder selection

Transdisciplinary projects require genuine consideration of key stakeholders and interest groups (Table 1). However, underlying socio-cultural contexts, as well as existing relationships and hierarchies, often facilitate preferential selection and involvement of stakeholders. While fruitful past collaborations with local and regional partners should be maintained, preferential inclusion of stakeholders can also hamper innovation and empowerment and result in biased project implementation teams.

Table 1. Comparison between three archetypical approaches to knowledge generation, policy development and implementation of conservation measures, with selected features. We note that while people/local communities can be (and in conservation funding projects regularly are) present in all three approaches, the transdisciplinary approach has distinct characteristics and it is an emerging feature of nature conservation research and practice.

Feature	Disciplinary approach	Interdisciplinary approach	Transdisciplinary approach
Teamwork	Knowledge is generated by a single or narrow range of experts. Biology-ecology, wildlife management (including i.e. 'hunters'), the social, cultural and economic dimensions of large carnivores in human-shaped landscapes can be addressed by different fields of disciplines without genuine interactions between them (Pohl et al. 2021).	Teams made up of members of knowledge groups collaborate on generate knowledge which then is integrated into a general understanding about large carnivores, environment and social system (Pohl et al. 2021).	Teams made up of different members of knowledge communities (academia, and legitimized stakeholders outside academia) work jointly for problem framing (project co-design), knowledge co-production and solution co-creation (Pohl et al. 2021).
Knowledge generating systems in relation to society	Fragmented, disconnected, elitist, self-referential, competitive, outcomes are available for relatively few, knowledge focused, informative (Caniglia et al. 2017; Kenter et al. 2019; Fazey et al. 2020).		Inter-connected, egalitarian, inclusive and equitable, reflexive, collaborative, outcomes available for everybody, wisdom focused, deliberative (Caniglia et al. 2017; Kenter et al. 2019; Fazey et al. 2020).
Intensity of researcher involvement	Embeddedness in the local social-environmental system is low. Members of the local community, if considered, are information sources and/or recipients of disseminated knowledge (Stauffacher et al. 2008).	Embeddedness in the local social-ecological system remains low, while interaction between team members with different expertise increases. Members of the local community if considered, are information sources and/or recipients of knowledge dissemination (Stauffacher et al. 2008).	Social-environmental embeddedness is high, ontological, epistemological boundaries of knowledge generation are identified and considered. The local community is considered as a partner (see previous points) (Stauffacher et al. 2008).
Institutional embodiment	Academic: specialised faculties and research centers. Policy and governance related: sectors (e.g. nature conservation, forestry, wildlife management, urban planning) with narrow focus (Hartel et al. 2019), political parties.	Academic: environmental science and multidisciplinary science faculties and centres. Policy and governance related: councils and committees with representative members for multiple knowledge groups (Hartel et al. 2019).	Academic: novel transdisciplinary working groups and courses within faculties. Policy and governance related: informal landscape stewardship groups, communities of practices, cross sectorial working groups (Hartel et al. 2019).
Representativity in the scientific literature of large carnivore conservation	High (Hartel et al. 2019; Lozano et al. 2019).	Moderate and increasing (Hartel et al. 2019; Lozano et al. 2019).	Low but appears as an emerging theme (Hartel et al. 2019; Lozano et al. 2019).
Representativity in the scientific literature related to the Natura 2000 protected area network of the EU.	High, with domination of ecology and landscape planning research and underrepresentation of social research (Popescu et al. 2014).	Moderate and increasing, with inclusion of human-nature connections and ecosystem service research (Popescu et al. 2014; Orsi et al. 2020).	Low and emerging (Winkel et al. 2015)
Representativity in large carnivore conservation projects	High, with example of topics such as biological surveys (Lupo/Appennino Reggiano project; Meriggi et al. 1998), species monitoring and reintroduction (LIFE Lynx project; Stergar and Slijepčević 2017).	Increasing, with example topics such as developing sustainable transportation (TRANSGREEN project; Murariu 2019), maintaining ecological connectivity (DINALPCONNECT project; Premelč et al. 2022; ConnectGREEN project; Meyer and Janz 2021), and livestock protection against large carnivore attack (LIFEstockProtect project; Benciolini 2021).	Low and under consideration through pilot projects dealing with coexistence (such as Life EuroLargeCarnivores project; Grossmann et al. 2020), or regional platforms on people and large carnivores (see e.g. Salvatori et al. 2020).

Feature	Disciplinary approach	Interdisciplinary approach	Transdisciplinary approach
Capacity to leverage human-large carnivore coexistence in human shaped landscapes.	Low, parameter level (sensu Abson et al. 2017; Hartel et al. 2019).	Moderate, by addressing multiple parameters and feedbacks at the level of formal disciplines and sectors (sensu Abson et al. 2017; Hartel et al. 2017).	High, by addressing deep leverage points such as value systems, architecture of collaborations and intentionality (Abson et al. 2017; Hartel et al. 2019).

Superficial involvement of stakeholders

Stakeholder meetings can facilitate a better understanding of human-large carnivore coexistence challenges and help identify and prioritise the most appropriate solutions (see the disciplinary and interdisciplinary approaches in Table 1). If stakeholder involvement processes are superficially designed and organised (Sayer et al. 2013; Carter et al. 2021), stakeholders might only have a consultative role, rather than an inclusive role required to build trust and genuine deliberations. Moreover, the lack of thorough follow-up and implementation of agreements, might also decrease the motivation for deep engagements in the future. Collaboration should not end with the formal ending of the project and the continuity of collaborative interactions will likely depend on the multiple group experiences gathered during the project implementation.

Failure to build on local social innovations

In some human-shaped landscapes, there may be a high level of innovation available for large carnivore conservation projects (Carter et al. 2021). Social innovations and associated processes can increase the sustainability of complex social systems (Wittmayer et al. 2022). However, failing to build on such local initiatives and knowledge, which can empower local communities, and ultimately increase trust and strengthen the relationship between the conservation sector and the society, also leads to TDD.

Monopoly of conservation projects by powerful leaders

Often partnerships are largely the same or at least similar, from project to project from local to even regional level, which dramatically limits the direct integration of valuable insights, views, and approaches of potential partners from other sectors. This is true, especially for entities with consistent abilities to attract project-based funding. While ongoing partnerships can be fruitful, a rigid partnership set-up can lead to saturation of ideas and approaches and ultimately low innovation potential, which can also contribute to TDD. True collaborative and inclusive project delivery methods should be embraced (Engebø et al. 2020).

Short project timeframes

Short projects inhibit genuine stakeholder interactions and deliberations and can also be a major limiting factor for identifying and consolidating genuine collaborative links with new partners. Short timeframes can mean that thorough preparations (research, data acquisitions, compilation of documents, etc.) are overlooked and stakeholder input

and feedback are not properly incorporated, and any solutions/recommendations are not tested. Commitment to continuous research is a crucial factor in transdisciplinarity (Huber and Rigling 2014). Overall, short-term projects have many drawbacks and can be prone to failure, especially if they address landscape scale initiatives (Sayer et al. 2013).

Stakeholder-profile related drivers

Low participation of key stakeholders

There are cases when stakeholders, with high level of expertise and/or knowledge and data, do not engage in projects, even if invited. This can reflect disappointment based on previous experience with other similar projects, scepticism about the capacity to generate consistent impact, disagreement regarding the proposed project objectives or approaches, and a lack of trust or genuine communication among stakeholders, incapacity to harmonize the project activities with the obligations towards other projects and institutions and/or the established culture of low engagement (Salvatori et al. 2020).

Powerful local groups

In certain human-shaped landscapes, powerful local leaders can monopolize the social and institutional networks and can enforce their involvement. Subsequently, they may seek to impose conditions for project implementation which are not in agreement with the broad project vision and may even be in conflict with the democratic participation of other locals (Treves and Santiago-Ávila 2020; Clark et al. 2021). Such local interests can prevent holistic approaches to large carnivore conservation.

Institution related drivers

Lack of cross-sectorial coordination

Strong sectorial cultures often result in the lack of agreed, shared visions between institutions and often represent a barrier for local sustainability initiatives including large carnivore conservation (Salvatori et al. 2020). On the other hand, there are cases when there is not enough institutional capacity and/or commitment among the responsible authorities to handle and consider the individual projects as key pieces contributing to a greater vision.

Institutional/sectoral conflicts

Large carnivore conservation and management can involve emotion-driven decisions, often leading to potential conflicts and divergent attitudes between nature conservation and game management. Such conflicts are historical and prominent in many European countries, obstructing the development of genuine collaboration and ultimately, transdisciplinary approaches. Moreover, such sectoral conflicts can directly drive human-wildlife conflicts (König et al. 2021).

Funding related drivers

Limitations on partnership possibilities by donors

Direct partnerships with private companies are not encouraged under the Life Programme, for example, unless they are specialised in sustainability consultancies (European Commission 2021a). However, there are various private companies which could contribute to large carnivore conservation.

Co-financing and/or cash flow requirements by funding programmes

The participation of academia and other entities in projects is often limited by co-financing and/or cash flow requirements. Universities and other institutions can add value through their research-oriented profile and increased capacity for driving and developing innovative concepts.

Ontological and epistemological drivers

Lack of transdisciplinary training in academia

Transdisciplinarity has a strong focus on co-creative and deliberative interactions (Table 1) and provides a genuinely new societal role for academia in sustainability transformations (Lawrence 2015). Besides the above mentioned challenges, the overly narrow disciplinary training within which formal academic training is acquired determines the ontological and epistemological bases of TDD. This is manifested through the inability of the representatives of formal sectors (i.e. wildlife management, forestry, agriculture, landscape and urban planning) to understand and approach the system outside the set of discipline related concepts and methodologies (Table 1; Hartel et al. 2019). This has a strong influence on how the experts trained in different disciplines and sectors perceive large carnivores in relation to people (López-Bao et al. 2017a). This is also often the root of several other type of tensions mentioned above.

The above mentioned 12 drivers can be particularly prominent in various socio-cultural and historical settings and can act alone, but most often in combination, compromising transdisciplinarity.

Contribution of conservation funding to human-large carnivore co-existence

Conservation funding plays an increasing role in shaping societal responses to global biodiversity loss (Waldron et al. 2013). This is especially true when multiple, and often conflicting interests and knowledge sets interact and the solutions are not fully satisfactory for different interest groups (e.g. López-Bao et al. 2017b; Buschke et al. 2019; Popescu et al. 2019; Salvatori et al. 2020; Marino et al. 2021). In the EU, there is public

funding aimed at directly facilitating wildlife conservation through the dedicated LIFE Programme (European Commission 2021a), which seeks to encourage best practice and demonstration projects, legislative compliance and enforcement, and public and stakeholder participation. There is also tangential funding for research, innovation and knowledge development (e.g. European Commission 2022a; BiodivERsA 2022), policy development and delivery (e.g. Interreg Europe 2022), improving skills, expertise and human capacity (e.g. European Commission 2022b), and education and experience exchange (e.g. European Commission 2022c). In principle, biodiversity enhancement is also possible under the Common Agricultural Policy, through the European Agricultural Fund for Rural Development (Heyl et al. 2020). However, whether, and to what extent, existing funding programmes foster transdisciplinarity is unclear.

We explored some of the most relevant funding schemes in this respect, while considering the key issues related to large carnivore conservation. These issues were formulated based on the knowledge needed to understand species requirements (carnivore biology and ecology), the key threat they face (habitat fragmentation), potential interactions with humans (human-large carnivore conflict types and their causes, and novel presence or re-establishment of large carnivores), conditions for nurturing acceptance of humans towards carnivores (stakeholder visions about the future of large carnivores, and communication, awareness and education), and other challenges in the long-term conservation of these species (large carnivores within the context of global change). We manually searched EU databases and sites for potential funding from key EU programmes (and sub-programmes), ranging from general funding (European Commission 2022d) applicable at the EU level, to more specific transnational programmes (Interreg 2022a). We checked the detailed description of the programmes and, where relevant, the applicant's guide to identify from concrete, to at least potentially relevant, funding opportunities in relation to large carnivore conservation, as well as co-financing requirements for beneficiaries. More specifically, each funding programme and sub-programme was assessed against its relevance and contribution to large carnivore conservation, namely for covering the key aspects mentioned above. The ones that were not relevant were ignored, and the rest included in one of the two main categories, namely dedicated (if there was a specific indication or reference to large carnivores) or tangential funding (if there was a rather broad reference to biodiversity or natural habitats). As the current EU programming period (2021–2027) has new/updated funding programmes, with no conservation projects yet implemented, we also evaluated the previous period (2014–2020). The list is not exhaustive; it indicates some of the most relevant sources that finance to some extent large carnivore conservation measures (e.g. there are several regional cooperation programmes, for which only one example was given).

Gaps in funding transdisciplinary actions

Our assessment of the issues concerning large carnivore conservation and the ability of EU funding programmes to address them is summarised in Table 2. Our assessment highlights that while local communities are present in large carnivore conservation projects, transdisciplinary approaches are not explicitly fostered in these projects. An idealised project

Table 2. Main issues, knowledge and action needs, and potential EU funding to address them in human shaped landscapes. *= actions which can be addressed through transdisciplinarity.

Key issues	Knowledge and actions needed to address the issue	Potential EU funding sources	Type of funding
Carnivore biology and ecology	Knowledge: Data regarding population size, distribution and dynamics of large carnivore populations, behaviour. Action: To develop sound management and action plans to assure biologically and ecologically viable large carnivore populations.	LIFE Programme Nature and Biodiversity sub-programme (European Commission 2022e) (co-financing rate expected from the applicant, 25–40%, depending on the targeted species and actions)	Dedicated funding
Habitat fragmentation/ ecological connectivity	Knowledge: Better understand how structural and functional connectivity are affected/ altered by the different types of human activities, including their cumulative effect on ecological processes. Action: To perform comparative analysis and assessment of how the different potential scenarios (including various infrastructure and other economic developments) or degree of fragmentation impede or facilitate ecological processes in the different landscapes where large carnivores are present. *Action: Involve human agency to identify and implement the best measures for maintaining ecological connectivity, including allocation land, agreement on human activities compatible with connectivity, etc.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		Interreg Europe (several regional programmes available, e.g. Danube Transnational Programme - Environment and Resource Efficiency (Interreg 2022b) (co-financing rate minimum 2%, up to 15–20% depending on the regional programme)	Tangential funding
		HORIZON Programme Food, Bioeconomy, Natural Resources, Agriculture and Environment – e.g. Environmental observation Research Area (European Commission 2022f) (no co-financing is usually needed for HORIZON projects for e.g. NGOs, while private companies need to ensure 30% co financing)	Tangential funding
Human-Large carnivore conflict types and their causes	Knowledge: Understand the types of damages caused by large carnivores, their frequency, spatial and temporal dynamics in each region. Action: To develop compensation and prevention schemes which are attractive for the human society and effective for conserving large carnivores, respectively contextualised for regions/ countries.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		Internal Security Fund (fight against environmental crime component (European Commission 2022g)) (co-financing rate minimum 10%)	Tangential funding
	Knowledge: Understand the social, environmental and biological mechanisms and triggers of human-large carnivore conflicts (e.g. supplementary feeding vs. habituation) in each region/country. *Action: involve human agency to prevent large carnivore caused damages (including in performing studies and research to better understand the mechanisms and triggers leading to human-wildlife conflicts).	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		HORIZON Programme Food, Bioeconomy, Natural Resources, Agriculture and Environment – Biodiversity Research Areas (European Commission 2022f)	Tangential funding
Stakeholder visions about the future of large carnivores, based on their present views and perceptions	Knowledge: Understand stakeholder visions about large carnivores and the possibilities to reconcile conflictual views. *Action: To develop community of practice type of cross sectorial institutional structures or platforms for genuine human-human interactions and continuous monitoring of the large carnivore populations within a social-ecological setting and to fine-tune conservation and societal goals.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding

Key issues	Knowledge and actions needed to address the issue	Potential EU funding sources	Type of funding
Communication, awareness and education	Knowledge: Understand the effectiveness of different types of communication and educational strategies and programmes in increasing the knowledge about, and the social acceptance of, large carnivores at local levels and beyond. *Action: To develop new and innovative tools and find ways (e.g. develop and implement a curriculum for efficient and interactive learning for children as well as adults) to effectively increase awareness and educate people towards improving coexistence with large carnivores.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		Development Education and Awareness Raising Programme (European Commission 2022h) (co-financing rate minimum 10%)	Tangential funding
		ERASMUS+ (European Commission 2022c) (typically co-financing rate minimum 20%)	Tangential funding
Novel presence or reestablishment of large carnivores	Knowledge: Understand the implications of living with large carnivores in areas where they were absent in recent history. *Action: To involve communities and their leaders in understanding the meaning, challenges and potential opportunities represented by the presence of large carnivores.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		European structural and investment funds - European Regional Development Fund, e.g. Interreg 2022b; CAP - European agricultural fund for rural development (European Commission 2022i) (typically co-financing rate is 50%, but it depends on the agreed national measures)	Tangential funding
Large carnivores within the context of global change	Knowledge: Understand the future implications of global/climate changes in human-shaped landscapes where large carnivores are present - particularly the level and patterns of coexistence between humans and large carnivores. *Action: To explore and assess possible scenarios for large carnivores and their habitats' distribution based on predicted climatic changes and prepare new adapted large carnivore conservation strategies and agile participatory decision making frameworks.	LIFE Programme - Nature and Biodiversity sub-programme (European Commission 2022e)	Dedicated funding
		LIFE - Climate Change Mitigation and Adaptation sub-programme - Climate governance and information (European Commission 2022j) (co-financing rate minimum 45%)	Tangential funding
		HORIZON Programme Food, Bioeconomy, Natural Resources, Agriculture and Environment – Adaptation to Climate Change Mission (European Commission 2022f)	Tangential funding
	Knowledge: Understand the norms and measures needed to allow coexistence between humans and large carnivores within a broader and changing environmental context. Action: To develop new forms of knowledge generation which facilitates paradigm shifts in large carnivore conservation.	LIFE - Climate Change Mitigation and Adaptation sub-programme - Climate governance and information (European Commission 2022j)	Tangential funding
		HORIZON Programme – Food, Bioeconomy, Natural Resources, Agriculture and Environment (e.g. HORIZON-EUSPA-2021-SPACE (European Commission 2022k)	Tangential funding

or programme on large carnivore conservation would address each key issue in Table 2; however, such a project or initiative is not possible under current funding programmes. Implementation would require several projects from various sources to be orchestrated and synchronised as part of a comprehensive large-scale strategy, which, in turn, is hindered by different human, institutional, administrative and financial barriers. Large carnivore biology and ecology, ecological connectivity related aspects, human-wildlife conflicts and communication are issues with a high degree of relevance within the available EU funding programmes. Nevertheless, stakeholder involvement actions in a transdisciplinary context are generally of a low to moderate degree relevance (Table 2). A transdisciplinary approach to large carnivore conservation can only be found in one Life project dealing with human-

large carnivore coexistence (Life Euro Large Carnivores; Grossmann et al. 2020; Table 1). There is no other mention of transdisciplinarity in the EC's library on large carnivores (https://ec.europa.eu/environment/nature/conservation/species/carnivores/library.htm).

Project beneficiaries are encouraged to apply for projects dedicated to single purposes or disciplines, e.g. biodiversity conservation. The resulting outcomes and outputs, although strong in many cases, are not necessarily fully compatible with socio-economic development or other societal needs. Outcomes are usually not long-lasting and thus the efficiency of spending is questionable. In addition, the functional effectiveness of various measures funded for improving coexistence with large carnivores is rarely assessed (Oliveira et al. 2021). Efficient spending of funds is questionable and remains a challenge for the recently commenced funding period. For example, in the period 2014–2020, seven large carnivore projects were funded by the Life Programme in 17 countries, amounting to 27 million euro. Romania received most of the funds (9.8 million euro), followed by Italy (6 million euro) and France (1.48 million euro) (European Commission-GISCO 2022). However, these funds have not necessarily resulted in substantial concrete and tangible results, yet. Slow progress towards achieving coexistence with large carnivores in these countries may partly be due to a lack of transdisciplinarity and coordinated approaches. Furthermore, the particularities and restrictions of different funding programmes, in terms of the eligibility of certain transdisciplinary types of actions, also inhibit coexistence. Donor-driven conservation, with few exceptions, is not compatible with integrated approaches to conserve large carnivores or other species' groups.

While our assessment indicates that transdisciplinarity is not yet explicitly encouraged by the EU funding programmes, there have been some improvements which resulted in the creation of the context where transdisciplinarity could be approached. For example, the LIFE's Integrated Projects for Environment sub-programme, which was available in the previous programme periods (European Commission 2021b), fully encouraged integrated projects to tackle general environmental problems, but no project was financed on large carnivore conservation or efforts focused on coexistence. The new Life Programme (2021–2027), continues to promote projects for integrated implementation of the EU biodiversity strategy (European Commission 2021c), allowing in principle, at least to some extent, for transdisciplinary approaches. Another promising approach is the new HORIZON Europe Programme (formerly known as "HORIZON 2020"), which seeks to promote new ways of thinking while addressing biodiversity conservation, namely through "transformative changes of the economy and society in both urban and rural areas" (European Commission 2022f). In addition, the EUs Common Agricultural Policy (Heyl et al. 2020; European Commission 2022i), which receives a significant part of the total EU budget (around 38% in the previous funding period and around 31% for 2021–2027; European Commission 2022l) could play a major role in improving coexistence with large carnivores (Marsden and Hovardas 2020), if damage prevention measures (e.g. electric fences, specialised guard dogs or secure shelters) funded through its second pillar, the Rural Development Fund (EAFRD), are operationalised across the entire EU and especially if transdisciplinary projects are promoted. In principle, EAFRD could support collaborative actions, including increasing knowledge and awareness, or even individual projects related to large carnivores; however, this is not one of its current practices (European Commission 2022l).

Conclusions

While we argue for a need to integrate transdisciplinarity approaches into large carnivore conservation, we emphasise that our intent is not to discredit disciplinary and interdisciplinary approaches and we do not intend to propose transdisciplinarity as a universal, single approach to solve every main large carnivore conservation challenge in human-shaped landscapes. We suggest that transdisciplinarity can be best achieved with (and not without) the legitimacy, involvement and wise use of robust, disciplinary knowledge alongside other, non-academic knowledge types.

Based on our assessment, we provide the following five recommendations to address the TDD in wildlife conservation projects: First, increase the transdisciplinary substance and character of public funding programmes for wildlife conservation. This can be done by explicitly mentioning and guiding transdisciplinary actions for multi-stakeholder engagement within funding rules. Second, foster the development of new conceptualisations for human-large carnivore coexistence in human-shaped landscapes through involvement of academia. Academia can assist large carnivore conservation projects through scientific knowledge, methods, research implementation, innovative tools, and data analysis. Third, encourage the development of communities of practice which set the ground for agreed solutions and measures for large carnivore conservation. This can be achieved by establishing landscape and large carnivore stewardship groups for key regions, with opportunity for involvement from every relevant sector and industry. Fourth, reduce co-financing rates for integrated projects to make funding programmes more attractive to all interested parties, some of which cannot meet current co-financing requirements. While transdisciplinary projects may increase the likelihood of successful conflict resolution, we recognise that in some cases stakeholder differences cannot always be harmonised (Van Dooren 2019). Fifth, our proposed 12 drivers leading to TDD could be integrated into a framework to address the transdisciplinary needs in various human-shaped landscapes. This would allow a better understanding of the relationships between the stakeholders before and after the implementation of different projects. Such an approach should eventually lead to improved development, implementation and outcomes of conservation projects and allow for critical and contextual comparisons between human-shaped landscapes, which can generate further insights and recommendations. Policy platforms such as the Carpathian Convention, the Alpine Convention or the EU Strategy for the Danube Region could facilitate such assessments at a greater regional level and foster improved coexistence with large carnivores by addressing the identified critical gaps in TDD as part of their continuous policy adaptations. In addition, with improved funding programmes from a transdisciplinarity point of view, future projects could gather insights to develop a broader and even more robust conceptual framework, within which the TDD in different regions could be better understood, assessed and addressed.

Societies in Europe and elsewhere are increasingly facing the challenge of adapting to climate change, political instability, human migrations, pandemics, food and water security and ongoing biodiversity decline. The conservation of large carnivores must occur within the broader context of these multidimensional and unprecedented

challenges. We need the formation of a new culture of collaboration which will form the basis for innovative solutions. Transdisciplinary conservation projects can be key instruments for triggering this culture.

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